Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Expanding Flexible Use of the 3.7-4.2 GHz Band	GN Docket No. 18-122

<u>DECLARATION OF DOUGLAS HYSLOP</u>

I, Douglas Hyslop, am over the age of 18. I am a resident of the state of Virginia. I have personal knowledge of the facts herein, and, if called as a witness, could competently testify to them.

1. I am Vice President of Technology and Spectrum Planning at CTIA. I have been asked by AT&T, Verizon, and CTIA to assess concerns raised that the operation of wireless telecommunications devices in the 3.7-3.8 GHz spectrum band (the "Initial 5G Deployment") will interfere with the operation of radio-based altimeters used in aviation in the band from 4.2-4.4 GHz (the "Altimeter Band"). For reasons explained in more detail below, I conclude that these concerns are unfounded.

- *First*, I conclude that the real-world deployment of 5G wireless telecommunications service in the Initial 5G Deployment does not create a risk of interference (much less harmful interference) with the operation of radio-based altimeters in the Altimeter Band. As a matter of the basic operation of radio waves, the 400 MHz distance from the top of the Initial 5G Deployment to the bottom of the Altimeter Band is more than sufficient to protect the Altimeter Band from interference. Moreover, voluntary commitments by AT&T and Verizon to temporarily limit the intensity of their 5G transmissions until July 2022 add yet an additional (and unnecessary) margin of protection, further eliminating any possible cause for concern.
- Real-world evidence confirms this technical conclusion. Nearly 40 countries have deployed 5G base stations in the C-Band, some with far less separation from the Altimeter Band than would exist here, and all without known reports of interference.

- I conclude that the RTCA study significantly departs from industry custom and practice and is sufficiently flawed as to be unreliable. It assumes unrealistic levels of interference sensitivity, makes unrealistic assumptions about radio wave behavior, draws conclusions based on the performance of antiquated aviation equipment, and departs from the methodology used to assess other radio equipment that poses a higher risk of interference to radio altimeters. When those methodological flaws are accounted for, the data from the study indicate that terrestrial wireless transmissions in the Initial 5G Deployment pose no risk of interference to radio-based altimeters.
- Finally, I have reviewed the emergency petition for relief filed on December 30, 2021 by Airlines for America and I conclude that the relief A4A requests is extremely broad and would hamper the delivery of 5G to a majority of the U.S. population.

A. Qualifications and Assignment

2. I hold a Bachelor's Degree in Electrical Engineering from the University of Virginia, and I have been an engineer in the wireless telecommunications industry for more than 30 years. I am the inventor or co-inventor on 44 patents involving wireless technology and system design, including wedge-shaped cells in a wireless communication system, concentric cells in a wireless communication system, air-to-ground communication system with separate traffic and control channels, architecture for simultaneous spectrum usage by air-to-ground and terrestrial networks, interference mitigation in an air-to-ground wireless communication network, and position information assisted beamforming.

3. In my current role, I provide guidance to members on the technical aspects of spectrum, coexistence with neighboring spectrum uses, and wireless technology. Recent projects include evaluating coexistence of 24 GHz 5G operations with NASA weather satellites, coexistence of unlicensed operations with Fixed Service microwave receivers in the 6 GHz band, and coexistence of cellular operations with wireless toll tag sensors.

4. Previously, I was Vice President, RAN (Radio Access Network) Engineering at SmartSky Networks, LLC, an aviation communications provider. In that role, I managed the

equipment vendor designing air-to-ground base stations and aircraft radios, including the air interface channelization, technical specifications, and radio filter design and selection. I worked with antenna manufacturers to develop beamforming antenna systems for both the aircraft and the ground station. I developed the unique wireless system design to maximize three-dimensional coverage for an air-to-ground system and performed modeling to quantify system performance. I managed the certification testing laboratory, witnessed testing, evaluated test reports, and provided supporting documentation to achieve FCC certification of the first generation base station and aircraft radio. I supported SmartSky sales engineers in meetings with aircraft manufacturers and equipment installers regarding the equipment specifications, installation requirements, and antenna placement on each aircraft model to ensure coverage and coexistence with other aircraft radio systems.

5. Prior to SmartSky, as an independent consultant I advised many companies on spectrum issues and suitable technologies for new wireless ventures. I performed theoretical analysis and laboratory and field testing for clients, and prepared studies and test reports for submission to the Federal Communications Commission. Systems assessed included wireless broadband technologies, satellite systems, fixed wireless, air-to-ground communications systems, and broadcast systems.

6. Earlier in my career, I led the deployment, optimization and operation of wireless systems in large cities. As a director at Nextel and later Sprint Nextel, I led the company's technology research team evaluating EVDO, WiMAX, LTE, and numerous proprietary wireless technologies.

7. I have served as an expert witness in wireless industry litigation, evaluating the coexistence and potential for interference from LightSquared/Ligado Networks L Band spectrum holdings to Global Positioning System (GPS) operations.

8. AT&T, Verizon, and CTIA have asked for my opinion whether the deployment of 5G wireless telecommunications service in the 3.7-3.8 GHz spectrum band will interfere with the performance of radio-based altimeters that operate in the 4.2-4.4 GHz band.[1] They have further asked me to assess the analysis submitted by RTCA, Inc.[2] (the "RTCA Report") to determine whether its methodology and conclusions are reliable and consistent with industry standards for assessing spectrum interference. Finally, they asked me to examine the relief sought by Airlines For America in its December 30, 2021 emergency petition for relief.

B. Deploying 5G in the Initial 5G Deployment Will Not Interfere With Radio Altimeters in the Altimeter Band

9. All of the available technical and real-world evidence point to the conclusion that deploying 5G in the Initial 5G Deployment will not interfere with radio altimeters in the Altimeter Band.

i. 5G operations in the 3.7-3.8 GHz band do not pose a risk to altimeter performance in the 4.2-4.4 GHz band

10. As a matter of basic radio wave behavior, interference is most likely to occur when simultaneous transmissions occur over the same frequencies — termed co-channel. When

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[1] I am aware that wireless carriers ultimately intend to transmit 5G signals at frequencies up to 3.98 GHz. I would reach the same conclusions for that larger band, but I have focused on the 100 MHz band from 3.7 to 3.7 GHz because that is the band in which transmissions are scheduled to begin most immediately.

[2] *See* RTCA, *Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations*, RTCA Paper No. 274-20/PMC-2073 (Oct. 7, 2020) ("RTCA Report"), attached to Letter from Terry McVenes, RTCA, Inc., to Marlene Dortch, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020)

transmissions share frequencies, their signals overlap and can disrupt one another. In contrast, when transmissions occur on different frequencies, interference is less likely. Two co-channel radios can interfere with each other if the signal levels are similar, or if the desired radio signal is weaker than the undesired signal. As an example, if a blue lamp and a red lamp are close to each other, the area of overlap will appear as purple light — the light levels are similar. As an observer walks closer to the red lamp, the color slowly shifts from purple to red, as the red light level becomes stronger and the blue grows weaker. Close to the red lamp, all light appears red; the blue lamp is far enough away, and therefore weaker, that the stronger red light dominates. Co-channel wireless systems behave similarly; if the desired radio's signal is strong enough, then no interference results. Coexistence requires a balancing of radio power levels and distance separation to control the co-channel interference.[3]

11. Radio frequencies operating on different channels do not interfere with each other because the energy falls within different portions of radio frequency spectrum. As a general matter, little to no undesired energy appears within the channel to which the receiver is listening. The deployment of 5G by wireless operators is unlikely to interfere with radio altimeters in large part because radio altimeter transmissions and C-Band transmissions will not occur on the same frequencies. Aeronautical radionavigation and aeronautical mobile services operate on the 4.2-4.4 GHz band (the "Altimeter Band"). The radio altimeters used on aircraft transmit and receive within this spectrum. On the other hand, 5G will be transmitted within the Initial 5G Deployment frequencies from 3.7-3.8 GHz in initial C-Band deployments, and later no higher than 3.98 GHz. The Initial 5G Deployment does not overlap with, and is not even directly adjacent to, the 4.2-4.4 GHz band.

[3] William C. Y. Lee, Ph.D, *Wireless and Cellular Telecommunications* at 45 (3d ed. 2006).

12. Because the only frequencies currently cleared for use are those from 3.7-3.8 GHz, radio altimeters operate in a frequency band that is separated by at least 400 megahertz from the C-Band frequencies. Even when the rest of the lower C-Band is cleared — which is anticipated to occur in December 2023 — there will still be at least a 220 MHz guard band between terrestrial 5G wireless services and radio altimeters. Those guard bands create buffer zones between the Initial 5G Deployment and the Altimeter Band that sharply reduces the likelihood of interference. Notably, I understand that the Commission has concluded that a 20 Megahertz guard band was sufficient to protect the Fixed Satellite Service earth station receivers - that will continue to operate in the upper C-Band (4.0-4.2 GHz) from the 5G transmissions just below.[4] The guard band between the Initial 5G Deployment and the Aviation Band is 20 times larger.

13. The signal strength of a potentially interfering signal is also highly relevant. An electromagnetic wave's power weakens dramatically with the distance it travels, according to the "inverse-square rule." When the distance a wave travels doubles, its intensity drops by four times. That means that waves emitted from a 5G base station begin to lose power at an exponential rate the moment they are transmitted. That is highly relevant in this case, because wireless operators generally point their 5G antennas toward the ground — to serve customers in buildings and on the ground. Any directly transmitted signal even reaching an airplane's altimeter (much less interfering with it) must have traveled the distance necessary — and suffered the necessary power loss — to go from the base station to a reflecting surface below it and back up to the airplane. That matters greatly here because the likelihood of interference decreases as (1) the distance between the transmitting and receiving frequencies increases and

[4] *C-Band Order* ¶¶ 30, 35.

(2) the power level of the competing transmission decreases. I further note that antennas are not perfect radiators, and some incidental energy is emitted directly above horizon. As this is wasted energy from the perspective of the base station, the antenna designer attempts to minimize this leaked energy.

14. It is my understanding that the power level the Commission has authorized for use in the Initial 5G Deployment is 1640 watts (62 dBm) per megahertz in urban areas, and 3280 watts (65 dBm) per megahertz in rural areas.[5] These power levels are not a cause for concern. The same power levels have been used in other spectrum bands, including the Personal Communications Service ("PCS")[6] and Advanced Wireless Service ("AWS") spectrum bands with tens of thousands of base stations operating throughout the United States.[7] Numerous licensees operate wireless networks in overlapping geographies and with frequency separations much, much less than the 400 megahertz separating the Lower C Band from the Altimeter Band.

15. Moreover, even to the extent that spurious emissions exist outside the Initial 5G Deployment and approach the Altimeter Band, those signals are dramatically weaker than the ones within the 3.7-3.8 GHz range and beyond the full protection of the guard band. I understand that leading equipment vendors have stated that C-Band transmissions will be -30 dBm/MHz or less at 4.2 GHz (the edge of where radio altimeters are authorized to operate) — which is *one and one-half billion times* lower than the maximum power per megahertz allowed for C-Band 5G operations in the Initial 5G Deployment.

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[5] 47 CFR § 27.50(j).

[6] 47 CFR § 24.232.

[7] 47 CFR § 27.50 (d).

16. Finally, the existence of adequate filtering technology further limits the potential for interference from out-of-band signals. In certain circumstances, a strong out-of-band signal at the receiver could still cause interference. For example, certain receivers intended to ensure the reception of low-power signals amplify incoming signal using what is known as a low-noise amplifier. And, in some cases, when the low-noise amplifier is set to amplify a weak incoming signal, a strong out-of-band signal can overload the amplifier. But there is a well-accepted solution to this circumstance: design the radio with what is known as a band pass filter located between the antenna and the low-noise amplifier. The band pass filter weakens strong out-of-band signals to a level tolerated by the receiver components, protecting the receiver from out-of-band interference. Almost all modern receivers include a band pass filter to attenuate signals outside of the receiver's operating band.

17. Indeed, such filters have been in use for decades. The early cellular systems in the 1980s provide an example of the use of receiver filters. The Cellular A Block and B Block spectrum were in adjacent bands owned by different licensees; if a B Block mobile was transmitting at very high power near an A Block base station, then the signal may have caused receiver overload. The cellular base stations included a filter that passed the desired block's frequencies and attenuated the other licensee's frequencies, preventing interference from the neighboring system using the immediately adjacent spectrum.[8]

ii. The major wireless operators' commitment to further voluntary restrictions will further ensure that C-Band transmissions will not interfere with radio altimeters

18. As noted above, the likelihood of interference decreases not only with increasing frequency separation between operations but also with decreasing power. Given the long and

[8] *Wireless and Cellular Telecommunications* at 45.

successful history with the authorized power levels, the large buffer between the Initial 5G Deployment and the Altimeter Band, and the abundant real-world evidence, there is no reason to expect interference with radio altimeters.

19. While currently authorized power levels provide no reason for concern, voluntary commitments concerning the use of 5G transmissions by Verizon and AT&T provide yet further reason to believe that deployment of 5G in the Initial 5G Deployment will not interfere with radio altimeters. I understand that Verizon and AT&T have voluntarily agreed to temporarily operate their 5G base stations using Initial 5G Deployment spectrum at power levels lower than that permitted by the FCC's C-Band Order. Specifically, AT&T and Verizon will limit C-Band effective isotropic radiated power ("EIRP") above the horizon for all 5G base stations to no more than 62 dBm/MHz (and less as the angle above horizon increases, reducing energy toward aircraft which are likely to be closer to the base station).[9] Similarly, they will limit C-Band EIRP below the horizon for all 5G base stations to no more than 62 dBm/MHz.[10]

20. Verizon and AT&T further agreed to temporarily reduce power even more in the vicinity of airports and helipads. These additional restrictions include limiting C-Band EIRP from 5G base stations to no more than 37 dBm/MHz within a particular area encompassing runways, and to 55 dBm/MHz within a larger perimeter; limiting C-Band power flux density ("PFD") to a maximum of -31 dBW/m^2/MHz at the surface of all paved runways, within the boundaries of the runway edges and runway threshold lines; limit C-Band PFD to a maximum of -19 dBW/m^2/MHz at the surface of all paved aprons and paved taxiways (i.e., movement and

[9] EIRP is a measurement of radiated output power from an ideal isotropic antenna in a single direction. An isotropic antenna is meant to distribute power equally in all directions. When that power is channeled into a single direction and measured, the power is known as EIRP.

[10] Letter from Verizon and AT&T, GN Docket No. 18-122 at 6-7 (Nov. 24, 2021) ("Verizon and AT&T Nov. 24 Letter").

non-movement areas); and limit C-Band PFD to -30 dBW/m^2/MHz at 300 feet within one nautical mile of a runway end.[11] For all public use heliports, the C-Band PFD will be no more than -16 dBW/m^2/MHz at the primary surfaces of helipads.

21. These temporary reductions and other precautionary measures are far more protective than what I understand the FCC to have required in the C-Band Order. Generally speaking, as the angle of their 5G signals increases above the horizon (that is, in the direction of aircraft), AT&T and Verizon will ensure further reductions in emitted power.[12] The nationwide limit on PFD above horizon reduces base station power toward aircraft by up to 14 dB, which is twenty-five times less power than the maximum power permitted in urban areas under the FCC rules. At a height of 300 feet above airports, the PFD limit reduces C-Band base station EIRP into the sky by approximately 14 dB over the FCC authorized levels. This condition will thus result in significantly lower emissions in navigable airspace. Moreover, the new safeguards will surround public airports with large zones in which any C-Band signals will be well below the levels successfully operating in many countries today. The FCC was correct when it stated that these additional precautionary measures are among "the most comprehensive efforts in the world to safeguard aviation technologies."[13]

22. Again, even without these additional precautionary measures there is no risk of interference with altimeters. With these measures, that conclusion is even clearer.

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[11] Verizon and AT&T Nov. 24 Letter at 6-7.

[12] *Id.*

[13] Matt Daneman, *AT&T, Verizon Limit C-Band Deployments Near Airports, Helipads Through July 6*, Communications Daily, at 2 (Nov. 26, 2021), https://bit.ly/3Jrj45f (quoting FCC spokesperson).

iii. Real-world evidence confirms that C-Band spectrum can safely be used for 5G without interfering with aviation equipment

23. In attempting to assess whether one transmission will interfere with another, it is also customary in wireless engineering to consider existing deployments that provide a natural experiment and real-world data. There is ample real-world data in this case, and it confirms that 5G transmissions in the C-Band — both in and above the Initial 5G Deployment — do not interfere with radio altimeters in the Altimeter Band.

24. In 38 countries, 5G signals are already being transmitted in the C-Band — and in at least one case, within a portion of the upper C-Band just 100 MHz away from the Altimeter Band. These countries include: Japan, South Korea, Taiwan, China, Hong Kong, Philippines, Australia, New Zealand, Singapore, Saudi Arabia, Bahrain, Oman, United Arab Emirates, Qatar, Kuwait, Greece, Spain, Italy, Austria, Switzerland, France, Luxembourg, Germany, Ireland, United Kingdom, Czech Republic, Denmark, Norway, Sweden, Finland, Latvia, Slovenia, Slovakia, Croatia, Hungary, Romania, Bulgaria, and Peru. I am unaware of reports of harmful interference with aviation equipment from any of these countries, and after a diligent search of regulatory authority sources have found none. None has been submitted in the record of this proceeding. Figure 1 below reflects the proliferation of 5G C-Band deployment.

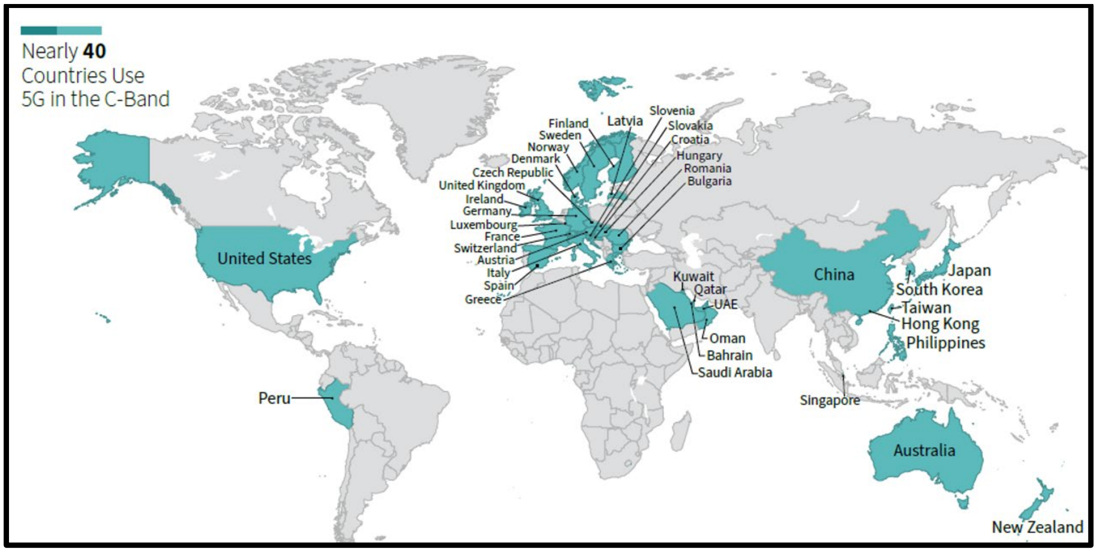

Fig.1.

25. On the contrary, these real-world deployments and careful study by industry and regulators across the globe all verify that 5G operations in the C-Band do not cause harmful interference to aviation equipment operating within the Altimeter Band.

26. Japan has deployed thousands of 5G base stations using spectrum up to 4100 MHz and above 4500 MHz — nearly adjacent to the Altimeter Band from below and above.[14] Japanese authorities assigned this spectrum to mobile service operators in April 2019.[15] Japan's regulators have required only 100 MHz of buffer on either side of the Altimeter Band — one fourth the size of the guard band between the Initial 5G Deployment and the Altimeter Band during initial 5G deployments in the U.S.

27. In Australia, carriers are successfully operating thousands of 5G base stations in the 3475-3700 MHz band, with a maximum 5G power level that is similar to the power level

[14] *Japan assigns 5G spectrum to four operators*, European 5G Observatory (April 16, 2019), https://5gobservatory.eu/japan-assigns-5g-spectrum-to-four-operators/; Letter from CTIA, GN Docket No. 18-122 at Annex A p. 19 (Sept. 3, 2021) ("CTIA Sept. 3 Letter").

[15] *Japan's 5G Markets*, U.S. Department of Commerce – International Trade Administration (May 26, 2020), https://www.trade.gov/market-intelligence/japans-5g-networks

specified by the FCC.[16] Australia auctioned this spectrum to mobile providers in 2018. The Civil Aviation Safety Authority in Australia has issued a public request for evidence of harmful interference by wireless services.[17] After a diligent search of regulatory authority sources, I am unaware of any known credible reports of interference.

28. The European Union recommended that member countries allocate the 3.4-3.8 GHz band for 5G, and did not set a mandatory limit to EIRP.[18] This includes the band segment where 5G operations will launch in the U.S. this year (3.7-3.8 GHz). I am unaware of any interference claims.

29. In preparing this declaration, I have reviewed Airlines for America's ("A4A's") Emergency Petition. The petition attempts to distinguish several real-world deployments of 5G in the C-band from Initial 5G Deployment in the United States. But the distinctions in the petition are not meaningful in this context. These countries' experience provide strong evidence that 5G operations in the C-Band do not cause harmful interference to aviation equipment.

30. A4A argues (at ¶ 21) that regulations in Japan cap base station power levels lower than FCC rules in the U.S. It notes (¶ 22) that in "most" of Europe permitted power levels are

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[16] The Australian regulator authorized base station power levels that are higher than the FCC technical rules. CTIA confirmed with wireless carriers in Australia that their operating base stations transmit with a maximum EIRP of 56 dBm/MHz, six decibels less than the urban regulatory limit in the United States.

[17] *See* Civil Aviation Safety Authority, *Report radio altimeter issues*, https://bit.ly/3mwVEBr (last accessed Dec. 31, 2021).

[18] *Review of the harmonised technical conditions applicable to the 3.4-3.8 GHz ('3.6 GHz') frequency band*, CEPT Report 67 to the European Commission (July 6, 2018), https://docdb.cept.org/download/118 (identifying recommended regulatory power limits across Europe). A subsequent European Commission Decision in January 2019 stated there is no mandatory limit to either non-AAS EIRP or AAS TRP. See *Commission Implementing Decision (EU) 2019/235 of 24 January 2019, on amending Decision 2008/411/EC as regards an update of relevant technical conditions applicable to the 3 400-3800 MHz frequency band*, Table 2, (Jan. 2019) https://docdb.cept.org/download/163.

23% lower, that in Australia (¶ 23) the limit is 76% lower, and that in the United Kingdom (¶ 24) the limit is 62% lower (in the analogous frequency band). Even assuming those figures are correct, they do not change my opinion about the conclusions that can be drawn from those other countries' experience. A4A's position that 5G deployment in the U.S. would be unsafe appears to be based on the RTCA Report; in the eyes of that report, the power differences A4A cites are meaningless. To take one example, the implication of the RTCA Report was that, in the case of "Category 2" aircraft (business and general aviation), 5G signals would be safe only at a level of 12 dBm/MHz.[19] According to A4A, Japan permits 5G base station power levels of 48 dBm/MHz — 36 dB stronger, or nearly *four thousand times higher*, than the RTCA "safe" level.[20] The absence of any notable interference in Japan despite what the RTCA Report would have termed a massive exceedance suggests that the report's analysis is flawed, and not that the small power-level differences cited by A4A are meaningful.

31. A4A also refers (at ¶ 22) to French "5G exclusion zones" but overstates the extent to which those exclusion zones are, in A4A's words, "consistent with the recommendations made previously to the Commission by U.S. aviation stakeholders." In France, base stations cannot be constructed within a narrow rectangle 910 meters (0.5 mile) of each side of the runway, extending 2100 meters (1.3 miles) beyond the runaway end. A larger zone (6100 meters (3.79 miles) from runway ends) limits power above the horizon. Moreover, the French military conducted trials studying helicopter radio altimeters and potential interference from an active 5G

[19] The RTCA Report claimed a Category 2 fundamental emissions exceedance of 48 dB, implying a 5G base station "safe" level of 12 dBm/MHz. RTCA Report at i.

[20] The standard unit of measurement for wave energy is the decibel (dB), and it is a logarithmic scale, rather than a linear scale. For example, an increase of 10 dB signals 10 times as much energy; an increase of 15 dB means more than 30 times as much energy; and an increase of 30 dB means 1,000 times as much energy.

base station. The study concluded that "the emission of 5G NR [new radio] base station had no impact on the operational behavior of the radio altimeter."[21]

32. A4A's isolated examples also overlook more relevant and more numerous comparisons. Seven countries (Denmark, Finland, Ireland, France, New Zealand, Romania, and Spain) operate in the same band that AT&T and Verizon will initially occupy (3.7 to 3.8 GHz) and are doing so with authorized power levels higher than the FCC's rules permit.[22] Two other countries' wireless operations (Czech Republic and Greece) largely overlap with the initial U.S. deployment and authorize the same or higher power levels. In my opinion, these apparently safe deployments indicate that A4A cannot be correct about the danger it says 5G poses at these levels and in these frequency bands.

33. Moreover, it does not appear that A4A's observations account for the voluntary temporary power-level commitments made by AT&T and Verizon, which include steps to "minimize energy coming from 5G base stations . . . to an even greater degree around public

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[21] ECC PT1(21)(192) (Sept. 6, 2021), https://www.cept.org/Documents/ecc-pt1/65970/ecc-pt1-21-192_franceradioaltimeter); *see also* Letter from CTIA, GN Docket No. 18-122 at 5 (Nov. 3, 2021) ("CTIA Nov. 3 Letter").

[22] *See, e.g.*, *Results of 3.6 GHz Band Spectrum Award*, Commission for Communications Regulations (May 22, 2017), https://www.comreg.ie/publication/results-3-6-ghz-band-spectrum-award/; *5G Action Plan for Denmark*, Energistyrelsen, https://ens.dk/sites/ens.dk/files/Tele/5g_action_plan_for_denmark.pdf; *Information Memorandum, Annex F, Draft 3.5 GHz Licence*, ENERGISTYRELSEN, at 2, https://ens.dk/sites/ens.dk/files/Tele/annex_f_-_draft_licence_3.5_ghz.pdf; *ANCOM's Position on awarding rights of use for the spectrum resources available in the frequency bands 694-790 MHz, 790-862 MHz, 1427-1517 MHz, 2500-2690 MHz, 3400-3800 MHz and 24.25- 27.5 GHz*, National Authority for Management and Regulation in Communications (ANCOM), at 23 (Jan. 2019), https://www.ancom.ro/en/uploads/forms_files/Document_pozitie_acordare_spectru_700_800_1500_2600_MHz_3,4-3,8_GHz_26_GHz_31_01_2019_en1573546318.pdf.
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airports," the locations of A4A's greatest stated concern.[23] With those commitments, U.S. 5G power levels in the vicinity of airports will be among the most restrictive in the world.[24]

34. Similarly, A4A observes (at ¶ 23) that the frequency band on which 5G operates in Australia goes no higher than 3.7 GHz. That distinction is not meaningful in this context. One need only observe the operations (cited by A4A itself) in Japan, which operates as high as 4.1 MHz, to conclude that the 400 MHz band protecting the Altimeter Band from the Initial 5G Deployment is more than sufficient to protect altimeters from interference.

35. Comparable evidence from within the United States bolsters the no-interference conclusion supported by the data across the globe. For example, radio altimeters currently co-exist near other high-power radio uses in the United States without reports of harmful interference to radio altimeters. There are two different Navy radars that operate slightly below the C-Band (just below 3.65 GHz) at power levels that are 10,000 times greater than 5G base stations.[25] From an engineering perspective, if a radio altimeter were designed poorly enough to be impacted by a signal 400 MHz away, then the same altimeter would be impacted by a signal 550 to 600 MHz away, especially given the much stronger signal levels of the Navy radar systems. Prior NTIA studies of the Citizens Broadband Radio System ("CBRS") spectrum noted the potential for significant interaction between the Navy radar systems and CBRS operations ashore,[26] providing clear evidence that the radars are used near U.S. coastal areas and place considerable energy into the sky where aircraft fly. In addition, federal aeronautical mobile

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[23] Verizon and AT&T Nov. 24 Letter at 2.

[24] *See id*.

[25] CTIA Nov. 3 Letter at 5; CTIA Sept. 3 Letter Annex at 19.

[26] Frank H. Sanders et al., *Using On-Shore Detected Radar Signal Power for Interference Protection of Off-Shore Radar Receivers*, NTIA Technical Report 16-521, U.S. Department of Commerce (March 2016).

telemetry systems operate in a frequency range (4.4-4.94 GHz) immediately above radio altimeters at power levels comparable to 5G base stations, with antennas in some cases pointed directly at aircraft.[27] I am unaware of any reports of interference with radio altimeters from either of these activities.

C. The RTCA Report Is Unreliable

36. It is my understanding that a report prepared by RTCA, Inc. (the "RTCA Report"), and a small number of updates thereto, is the primary evidence being cited in support of the conclusion that deployment of 5G in the Initial 5G Deployment will interfere with radio altimeters in the Altimeter Band. I have reviewed that report and the history of its development.

37. RTCA prepared the report using experimentation data from the Aerospace Vehicle Systems Institute ("AVSI"). AVSI comprises major aerospace companies and government organizations that collaborate on research important to its membership. AVSI tested the performance of nine radio altimeters exposed to 5G signals in a limited number of simulated 5G scenarios. RTCA then purported to combine those limited and preliminary results with a host of "models and assumptions to predict the received interference levels across a wide range of operational scenarios,"[28] and then to reach conclusions about the real-world risks to altimeter performance from 5G.

38. I have carefully reviewed the RTCA Report, the assumptions it made, and the underlying data that have been made available,[29] and I have considered the RTCA Report's consistency with how risk of interference is typically assessed as a matter of sound engineering.

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[27] CTIA Nov. 3 Letter at 5; CTIA Sept. 3 Letter Annex at 19.

[28] RCTA Report at i.

[29] The underlying AVSI data that formed the basis for the RTCA Report. Some data was only made publicly available as recently as in a filing dated December 6, 2021.

I conclude that the report suffers from a range of methodological flaws that depart significantly from the standard ways industry engineers assess interference and the risk of harm therefrom. Those deviations make it impossible to rely on the results of the study.

i. The RTCA Report contains numerous methodological flaws

39. It is critical in any study of interference to define precisely what will constitute harmful interference with the radio performance at issue. Ideally, a test for interference will find interference to be present in, and only in, the same situations in which interference would be present in the real world. A test that is insufficiently sensitive will miss interference that could arise in real-world situations. By contrast, and equally importantly, a test that is too sensitive will find interference to be present even though none in fact would be. Such an overly sensitive test can lead to the mistaken conclusion that the tested technology poses risks of harmful interference that it in fact does not. The RTCA Report contains numerous errors of this sort.

<u>Margin for Signal Loss</u>

40. A radio wave's signal strength decreases over distance and can scatter when it his objects that are not perfectly reflective (such as rough or angled surfaces). A standard performance test for altimeters is to assess altitude accuracy in a laboratory environment under test conditions reflecting the worst situations encountered in real-world landing scenarios. A key input is how much signal strength (measured in dB) is lost in a normal transmission from the altimeter to the ground and back up.[30] Some signal loss is inevitable; signals returning from the ground will be weaker than whey they left the airplane. That reduction in signal strength is known as "loop loss," and depends largely on the reflectivity of the terrain underneath the

[30] Radio altimeters work by sending a signal to the ground that is reflected back, and then calculating altitude based on the travel time of the reflected signal.

aircraft. The worst case level of loop loss for radio altimeters is well accepted — -88 dB at 200 ft. of altitude.[31] AVSI's 5G test conditions exceeded that figure in several ways.

41. First, AVSI used an incorrect starting assumption of 90 dB (not 88 dB) of loop loss because it assumed the altimeters to have a 60-degree beam width altimeter antenna, when nearly all civilian antennae use a 45 degree beam width antenna.[32] Second, AVSI assumed 6 dB for transmit and receive cable losses, for a total loop loss of 96 dB.[33] This was inappropriate, as RTCA's own standard for measuring altimeter performance does not require cable loss to be assumed in addition to loop loss.[34] Thus, AVSI's 5G test conditions required altimeters to operate successfully with 8 dB worse signal (more than six times worse) than the worst case requirement of DO-155.

42. On top of that, the RTCA Report disclosed that it added an additional 6 dB of margin to account for certain aspects of the test setup,[35] and yet another 6 dB in "safety margin."[36] The result was that the RTCA Report required altimeters facing potential 5G interference not only to perform better than the standard acceptable loop loss but to do so with an additional margin of 12 dB. The effect of that 12 dB addition alone was to require the altimeters to detect a returning signal 15 times weaker than is usually required in testing. And, when combined with the 8 dB added by AVSI, the result was to require the altimeters to detect a signal

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[31] *See* RTCA, Inc., DO-155, *Minimum Performance Standards Airborne Low-Range Radar Altimeters*, Appendix B at 8, figure 4 (Nov. 1, 1974) ("DO-155"). Figure 4 is appropriate given the prevalence of civilian altimeter antennas with 45 degree beam width, as noted in the CTIA Sept. 3 Letter Annex at 15-16.

[32] October 2019 AVSI Report at 7.

[33] RTCA Report at 37.

[34] Letter from CTIA, GN Docket No. 18-122 at 6 (Mar. 4, 2021).

[35] RTCA Report at 40-41.

[36] RTCA Report at 19.

20 dB, or 100 times, weaker than normal testing conditions. I am aware of no industry custom or practice, nor of any real-world fact, that justifies that margin.

43. Considering a distinct wireless technology illustrates the point. In 2019, AVSI evaluated the potential that wireless avionics intra-communications, or "WAIC," technology would interfere with radio altimeters. WAIC devices reduce the weight of an airplane by using wireless signals to transmit information that would otherwise be carried by a physical wire. WAIC devices will operate in the same spectrum band as radio altimeters and would be installed onboard the same aircraft. The WAIC antennas would most likely be installed within line-of-sight of the altimeter antennas. The likelihood of interference increases due to the co-channel nature of WAIC within the Altimeter Band, and given the close physical proximity of the WAIC transmitters to the altimeter receive antennas. All else equal, then, a WAIC signal is *more* likely to cause interference. Yet in the WAIC study, the AVSI applied a loop-loss of 90 dB.

44. As with 5G, AVSI incorrectly assumed a 60-degree beam width altimeter antenna. To that, however, it added just a small 2 dB margin for a total loss of 92 dB.[37] Thus, when evaluating 5G, RTCA used test conditions and margins that were 16 dB more stringent, or nearly 40 times worse, than those employed by AVSI in the WAIC evaluation. Had RTCA applied the same test conditions and margins as it did with WAIC, every Category 1 altimeter would have been found not to be subject to interference from 5G signals.[38]

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[37] *See Radio Altimeter-WAIC Interference Susceptibility Testing Status Update*, FSMP WG9, ICAO Montreal, Canada, at 9 (Aug. 22-30, 2019) ("FSMP WG9").

[38] RTCA Report, at i, claimed an exceedance by the worst Category 1 altimeter of 14 dB, inclusive of all margins. If the 5G test conditions were consistent with the prior WAIC testing, then the 16 dB better test conditions would have offset the 14 dB claimed exceedance, and all Category 1 altimeters would have shown acceptable performance.

45. As noted above, RTCA used 12 dB of additional margin here, with 6 dB attributed as test and manufacturing margins[39] and 6 dB as an ICAO safety margin.[40] Beyond this margin, AVSI added a further 6 dB of cable loss to 5G that was not present under WAIC. And AVSI did not also consider cable loss when assessing the interference potential of WAIC.[41]

46. Regarding the ICAO safety margin in particular, this margin was not included with WAIC. I do not see a justification for using that much larger "safety" margin in the 5G case and a much smaller margin in the WAIC case. As explained above, 5G operates in the Initial 5G Deployment, which is not only outside the Altimeter Band, but separated by 400 MHz of frequency as a buffer. The RTCA approach of considering the worst case for every input and test condition more than negates the necessity of further margin; indeed, in my opinion the scenarios envisioned within the RTCA Report would not occur in the real world.

47. As a general matter, margins can be a useful tool to account for emergency situations, factors that cannot easily be tested in a laboratory, or equipment variations. But margins must be realistic to be useful. They must not be made so large as to eliminate the possibility that the test can be passed. To take a simple example, imagine a highway underpass with a clearance of eight feet. In asking whether a truck that is seven feet, eleven inches tall would fit underneath, one might add a margin of a few inches to account for factors that might elevate the truck by a small amount — say, a bump in the road or overly inflated tires. One might conclude on that basis that the truck might not fit under the pass despite its normal height.

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[39] RTCA Report at 40.

[40] *Id.* at 19.

[41] *See* FSMP WG/9 ("DO-155 does not specify installation requirements including cable loss values. Thus we assume cable loss of 0 dB for both the WAIC interference and the RA return signal.").

It would be wholly unrealistic, however, to reach the same conclusion about a sport utility vehicle that was six feet tall. Even leaving a safety margin, there would be no possibility that the car and the underpass would collide. To nevertheless conclude that the SUV would not fit under the pass would impose a costly limit on the SUV's, and the road's, usefulness. That is the sort of error the RTCA Report committed here.

<u>Empirical Assumptions</u>

48. The RTCA Report also erred in establishing the performance parameters the altimeters had to satisfy without being affected by interference in order to be considered safe. AVSI's altimeter interference tests include a "worst case landing scenario" or "WCLS." Although ensuring altimeters will perform in difficult circumstances is obviously important, test parameters must nevertheless be realistic in order to be useful (just as with margins, discussed above). If a cruise ship were not considered seaworthy unless it could float under the weight of ten million people, then it would never be allowed to sail, even though it would never need to perform such a feat.

49. The RTCA Report modeled the altimeters' performance under a WCLS that assumed an airplane flying at 200 feet above the runway threshold; a runway threshold that is rough rather than smooth (and so would cause more loss of the desired altimeter signal); and "sixteen aggressor aircraft" emitting interfering signals from their own radio altimeters, fourteen of which would do so with perfect ground reflections.[42]

50. I do not opine on the realism of that scenario from an aviation perspective, but I do observe the following. First, it is not customary from a wireless engineering perspective to

[42] RTCA Report at 106-09.

assess radio interference in conditions that do not resemble those found in the real world or in scenarios that are not legally permissible.

51. Second, to further explain the ground surface reflectivity assumptions, the RTCA Report assumed that the "aggressor" signals would be emitted downward from parked airplanes and reflect perfectly off of the ground at the airport before pointing skyward as potential interference; that assumption means that the ground surface must be smooth, not rough, because rough surfaces do not reflect perfectly. Despite that assumption, the report also assumed a rough runway that would disrupt the effective wave reflections of signals from a landing radio altimeter. The report does not explain why the ground in the WCLS would be simultaneously smooth and rough. It appears that AVSI selected these testing parameters to maximize the potential for interference, rather than because they are likely to occur in the real world.

52. The errors in AVSI's approach to the Worst Case Landing Scenario artificially worsened the test results for the Category 1 (commercial aviation) and 2 (general and business aviation) altimeters at 200 feet. I believe that RTCA's conclusions for those categories cannot be relied upon given these fatal flaws in the AVSI test data — the combination of the overstated ground-based interference to a landing aircraft and the inconsistent treatment of surface reflectivity are an unrealistic scenario not resembling a real-world landing approach. AVSI's WCLS test conditions exposed the altimeter under test to unrealistically harsh conditions that artificially worsened the altimeter's response to injected 5G signals.

53. To further emphasize this point, AVSI noted that the loop losses included in the more lenient WAIC testing were conservative: "It is widely recognized by RA manufacturers that these values are typically more conservative than values seen in practice in modern RA

installations."[43] It expanded on this point by stating, "Given these conservative assumptions for the DO-155 loop loss, it is expected that an additional 10-12 dB of margin would be experienced in a typical real world landing scenario."[44]

54. I estimate that the assumption of a rough runway (at an otherwise smooth airport) degraded the landing radio altimeter's signal strength by 15-20 dB — a reduction of 30 to 100 times the desired signal. In August 2019, AVSI agreed that the more lenient WAIC testing would yield 10-12 dB better performance in a real world landing scenario, lending credence to my opinion.[45]

55. In addition to the WCLS analysis, the RTCA Report assessed the intensity of incoming 5G signals by assuming an airplane that was pitched (nose-up or nose-down) or rolled (wings tilted left or right) at an angle of at least 20 degrees. At such a pitch or roll angle, the report concluded that interference would occur *below* 250 feet in the air.[46] Again, I do not opine on the realism of a 20-degree pitch or roll that close to the ground. I do observe, however, that RTCA was able to cite just one real-world instance of such a pitch or roll angle at a low altitude and it was *at* (not below) 250 feet of altitude: the southward landing approach to Reagan National Airport in Washington, D.C. The RTCA Report cite *no* examples of such a maneuver below that altitude (where it concluded interference was a risk). It further acknowledged that "most operations of Usage Category 1 aircraft at low altitudes will *not involve* significant pitch or roll angles."[47] From a modeling perspective, this suggests to me that the report again created

[43] FSMP WG/9 at 11.

[44] *Id* at 24.

[45] *Id.*

[46] RTCA Report at 204-05.

[47] *Id.* at 205 (emphasis added).

a scenario designed to maximize potential interference, rather than one that could possibly occur in the real-world. Such a modeling approach does not have useful real-world applicability.

56. In addition, the RTCA Report erred in modeling the dissipation of the 5G signal strength reaching airborne aircraft. For example, RTCA's modeling employed a propagation model known as "P.528,"[48] which is typically used in predicting signal strength over long distances, not over the relatively short distances driving the RTCA claims. That incorrect propagation model increased the 5G signal at the aircraft by several dB. RTCA relied on an incorrect base station Advanced Antenna System (AAS) pattern,[49] which placed more 5G energy into the sky than would result in actual operations. The RTCA Report also failed to consider fuselage attenuation; landing aircraft at lower altitudes would not present a line-of-sight propagation path to the surrounding base stations. Rather, the metal fuselage of the aircraft would greatly attenuate, or potentially completely block, the 5G signals from reaching the altimeter antennas. CTIA corrected these flaws and modeled the worst case intensity of 5G signals at landing aircraft from the closest possible base stations from an obstruction clearance perspective, and noted a significantly lower signal strength than that incorrectly modeled by RTCA.[50] The CTIA analysis indicated that 5G signals would be at least 18 dB lower than the RTCA assumed level, and generally much lower than that.

57. The RTCA Report also ignored basic realities of 5G that would reduce experienced power levels even farther below these worst case calculations. For instance, in operation, a 5G base station serves multiple customer devices, forming separate beams to each

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[48] RTCA Report at 18.

[49] RTCA Report at 19.

[50] CTIA Sept. 3 Letter Annex, at 24, modeled a 5G signal at the aircraft of -32 dBm/100 MHz, 18 dB lower than RTCA's signal level of -14 dBm/100 MHz.

device. The result is that the base station's power capacity is not placed into a single beam (as the RTCA Report appears to assume[51]), but instead is spread in several directions, diffusing the magnitude of 5G energy above horizon in any given direction. Further, without multiple beams, a 5G base station is not designed to operate at 100% occupancy, since at that loading level, new customer requests are rejected.

<u>Testing Equipment and Data Manipulation</u>

58. Consistent with the foregoing, it is important in conducting interference testing to run the test against equipment that is representative of the equipment that will be encountered in the real world. Here, too, the RTCA Report's methodology departed from sound engineering testing principles.

59. First, the RTCA Report relied on AVSI experimentation data that did not disclose the altimeters used. That is inconsistent with sound engineering experimentation protocols because it makes it impossible to assess the real-world applicability of the results — put differently, it makes it impossible to know if the test results are relevant to equipment used on real airplanes.

60. The only information the RTCA Report disclosed was that AVSI tested "nine radar altimeter models[] from five different manufacturers" that are "considered" — the report does not say by whom — "to be generally applicable across all present civil aviation applications."[52] The report also disclosed that eight of the nine models utilize frequency-modulated continuous wave radar technology, while one uses unmodulated pulsed radar

[51] *See* RTCA Report 19-24 (omitting any mention of multi-beam beam-forming).

[52] RTCA Report at 34.

technology.[53] It is important to observe at the outset that manufacturers rarely use pulse radar technology anymore; as the RTCA Report itself states, frequency-modulated continuous wave (as opposed to pulsed) radar is "far more common among [altimeter] models developed in the last few decades."[54] It is not consistent with sound engineering testing protocols to assess interference using undisclosed or antiquated equipment. RTCA's decision to do so leads me to question the RTCA Report's results.

61. Second, after testing those concealed altimeters, the RTCA Report selected "the worst-case interference tolerance threshold across all altimeter models" within a given category of altimeters. The RTCA Report divided the aviation world into three categories: "Category 1," commercial air transport airplanes; "Category 2," all other fixed-wing aircraft, including business and general aviation airplanes; and "Category 3," helicopters. The RTCA Report assumed that five of its altimeter models were used by Category 1 airplanes and that the other four were used in Category 2 and 3 aircraft.[55] In determining whether interference was a risk, the RTCA Report considered only the performance of the *worst* performing altimeter in each usage category.[56] It then treated that altimeter as representative of the performance of *all* the altimeters used by aircraft in that category even though, by hypothesis, it was not — it was worse. That decision was not consistent with sound engineering and testing principles. Even assuming any interference, the RTCA Report's approach would have led it to conclude that far more altimeters would be subject to interference from 5G, through their flawed methodology, than would be the case with an impartial process evaluating real-world conditions.

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[53] *See id.*

[54] *Id.* at 2.

[55] *See id.* at 34-36.

[56] *See id.* at 35.

62. Recently released data confirms that this "worst-case interference tolerance threshold" approach had a large and material effect on RTCA's conclusion. More than a year after the RTCA Report's publication, the AVSI disclosed for the first time the characteristics of the radio altimeters analyzed in the RTCA Report.[57] As noted above, the AVSI report discloses that *four of the five* altimeters tested in the RTCA Report's "Category 1" (altimeters used in commercial aircraft) were found *not* to be subject to interference even under the RTCA Report's totally unrealistic testing assumptions.[58] The RTCA Report's conclusion that Category 1 altimeters would be subject to interference was reached on the basis of the single worst performing altimeter — which was the *only* altimeter not to satisfy the RTCA's unrealistically sensitive conditions. Moreover, the one altimeter not to satisfy RTCA's unrealistic standards likewise experiences no interference when appropriate conditions are modeled. Simply correcting the unfavorable margins and removing the cable loss not employed in the WAIC testing would clear the one altimeter that RTCA claimed as the interference event driving Category 1 exceedance.

63. The RTCA Report's conclusions concerning Category 2 (business and general aviation) and 3 (helicopters) altimeters is likewise affected by this sort of error. The worst performing Category 2 and 3 altimeter was a "pulse" altimeter that was designed decades ago, as a pulsed altimeter has not been certified by the FCC since at least 1980. [59] To my knowledge, all

[57] *See* Aerospace Vehicle Systems Institute ("AVSI"), *AFE 76s2 Report: Derivation of Radar Altimeter Interference Tolerance Masks, Volume I: Introduction, Test Procedures, and Fundamental Test Results* (Dec. 6, 2021) ("AVSI AFE 76s2 Volume I Report"), *attached to* Letter from David Redman, AVSI, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Dec. 6, 2021).

[58] *See id.* at 3-32 – 3-33. Comparing the AVSI test results at which the pass/fail criteria were exceeded to the worst RTCA 5G signal level modeled showed at least 5 dB of available margin.

[59] Letter from CTIA, GN Docket No. 18-122 at 7 (Oct. 27, 2020).

other commercially available civilian radio altimeters employ the more modern Frequency Modulated Continuous Wave (FMCW) technology. The performance of this single altimeter was significantly worse — up to 50 dB more interference — than the two leading altimeters in those categories.[60]

64. AVSI also employed "pass/fail criteria" that were more stringent than the levels used by the FAA to test altimeters for flightworthiness; in other words, it required the altimeters to be more accurate than even regulators require them to be — a situation almost certain to produce false "failures." The FAA TSO C87a provides guidance on the minimum performance criteria for radio altimeters, referencing the requirements within EUROCAE ED-30; that guidance specifies that altimeters must accurately detect altitude within a 3% margin for altitudes 500 feet and below, and a 5% margin above 500 feet. AVSI applied a pass/fail criteria that registered a failure for a mean height error greater than *0.5%*, and a failure if a small number of measurements exceeded a *2%* error — more stringent than the accepted minimum performance requirements. The AVSI data publicly released in December 2021 illustrate that its artificially high standard infected its results. For example, AVSI noted that altimeter model I reports altitude in 5-foot increments, meaning when testing at 200 feet, a measured altitude error of 203 feet would be reported as 205 feet. The reported height would exceed AVSI's 2% criteria and fail, even though it would pass the 3% industry-standard test. This deviation by AVSI from industry standard testing makes it impossible to trust the conclusions RTCA drew from that underlying data.

65. RTCA's deviation from the standards used in previous studies provides an additional reason for concern. As noted above, a 2019 AVSI study of WAIC technology

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[60] *See* AVSI AFE 76s2 Volume I Report at 3-120.

concluded that WAIC does not interfere with radio altimeters; WAIC has been authorized to operate within the Altimeter Band. That study did not use an antiquated pulse altimeter to test the potential for WAIC to interfere with radio altimeters.[61] Had AVSI included the same pulse altimeter used in the RTCA Report, AVSI's findings would have been different. WAIC's interference would have exceeded the permissible level used in the RTCA Report by 34 dB.[62]

ii. Correcting the flaws in the RTCA's methodology results in findings of no interference

66. From a wireless engineering perspective, I believe that the RTCA applied 12 dB of inappropriate margin to the study results. AVSI incorrectly applied a further 6 dB of cable loss, and was in error by 2 dB regarding the starting loop loss. RTCA's 5G signal modeling over-estimated 5G signal arriving at the aircraft by at least 18 dB. And the loop loss employed in a landing scenario, based on the assumption of roughest terrain, is overly stringent by 15-20 dB. These corrections amount to a difference of 53 to 58 dB, which is more than sufficient to offset the RTCA's claimed exceedances. The preceding calculations do not consider the underlying issue of the unreliability of the AVSI test data, given the faulty pass/fail methodology employed. (I do not rule out the possibility that other assumptions, such as those made about aviation, also led to an overestimation, but I do not opine on those.)

67. Adjusting only the Category 1 interference findings to account for the disparate treatment applied to margins and cable loss for 5G versus WAIC, as derived above, eliminates entirely the RTCA Report's finding of interference for the altimeters used by the major commercial airlines in the United States. The Category 2 flawed test conditions, consisting solely of the WCLS measurements at 200 feet, lack merit due to the technical flaws in the setup.

[61] *See* FSMP WG9 at 2.

[62] *See* FSMP WG9 at 23-24.

Correction to the remaining factors, as noted above, illustrates how the Category 3 radio altimeters would also coexist with 5G without interference.

D. A4A's Requested Relief

68. In its request for relief, A4A asks the FCC to stay the initiation of 5G services in the C-Band from all towers near 135 airports across the country and that are in 46 PEAs and references (¶ 9) a radius of 42 miles around such towers as the subject of possible FAA action. Relief of that sort would not be limited and would prevent deployment in large portions of the country.

69. Exhibit 1 lists the 135 relevant airports. The areas that these airports serve include 21 of the 25 most populous metropolitan statistical areas in the United States, including those of New York, Chicago, Miami, and Los Angeles.[63]

70. Texas illustrates the severity of such relief. The active PEAs in Texas include PEA 8 Dallas/Fort Worth, PEA 10 Houston, PEA 28 San Antonio, PEA 35 Austin, and PEA 47 Brownsville. The Dallas/Fort Worth area is almost completely encompassed within a 42-mile radius of Dallas Fort Worth International Airport and Dallas Love Field Airport — no base stations in those areas would be permitted to transmit 5G. The perimeters surrounding Hobby Airport, George Bush International Airport, and Ellington Airport would cover all antennae in Houston and its vicinity. Similarly, Austin, San Antonio, and Brownsville are all served by airports – all listed on Exhibit 1 – that operate within the metropolitan area, meaning that, there, too, all base stations would be forced to remain off, as the below figure illustrates.

[63] United States Census Bureau, *2020 Population and Housing State Data* (Aug. 2021), https://www.census.gov/library/visualizations/interactive/2020-population-and-housing-state-data.html

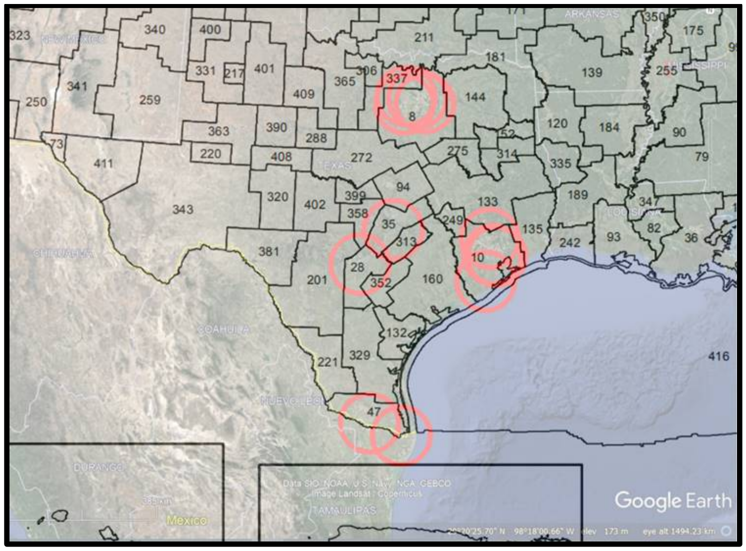

Fig.2.

71. Moreover, the 42-mile figure makes little sense to me as an engineering matter. At that distance from a base station, considering antenna pointing, curvature of the earth, clutter and propagation losses, a 5G signal is barely detectable, much less capable of causing harmful interference.

72. It is my opinion that, the relief discussed would bar all 5G expansion reaching the most populous areas of Texas — and the majority of the population of the United States.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on December 31, 2021, in Virginia.

Douglas Hyslop